

In situ ocean observations

Guillaume Maze, Ifremer

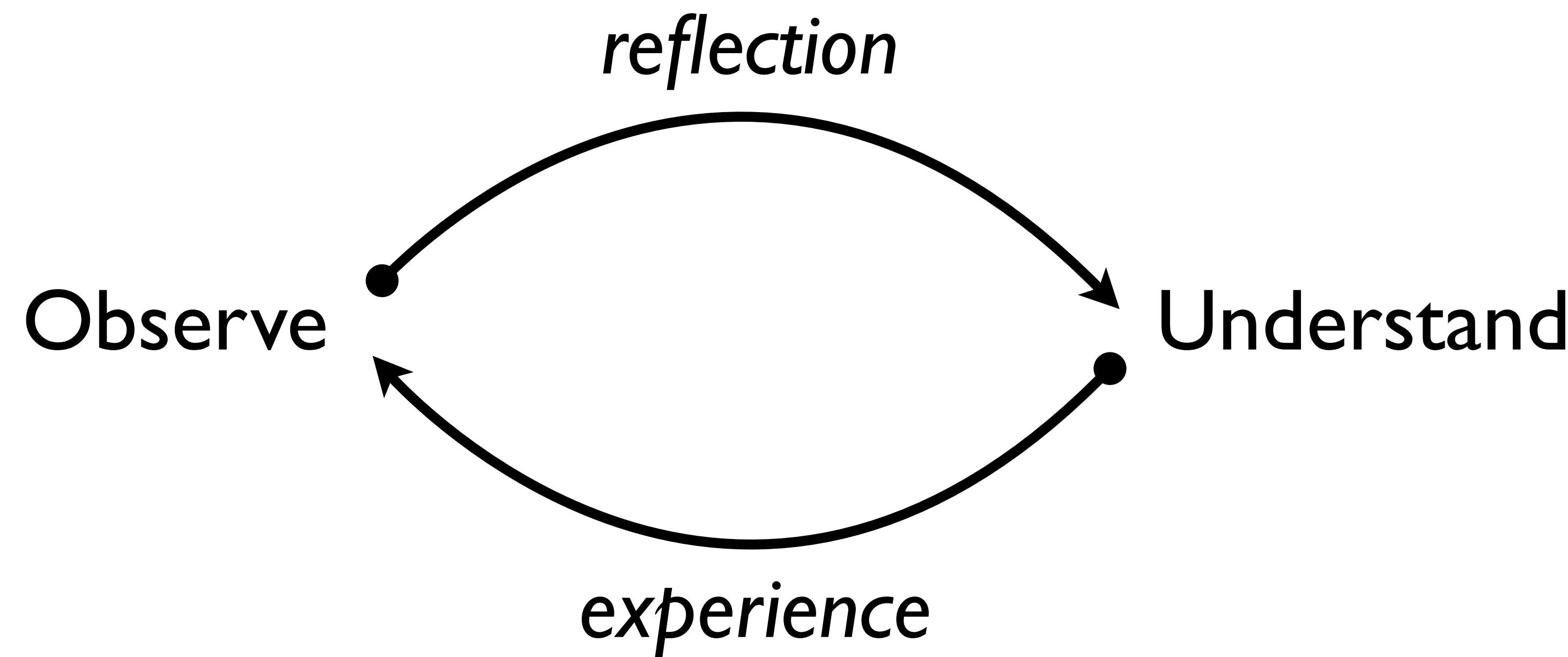
Laboratoire d'océanographie physique et spatiale (LOPS)

Diderot, "Thoughts on the interpretation of nature", 1754

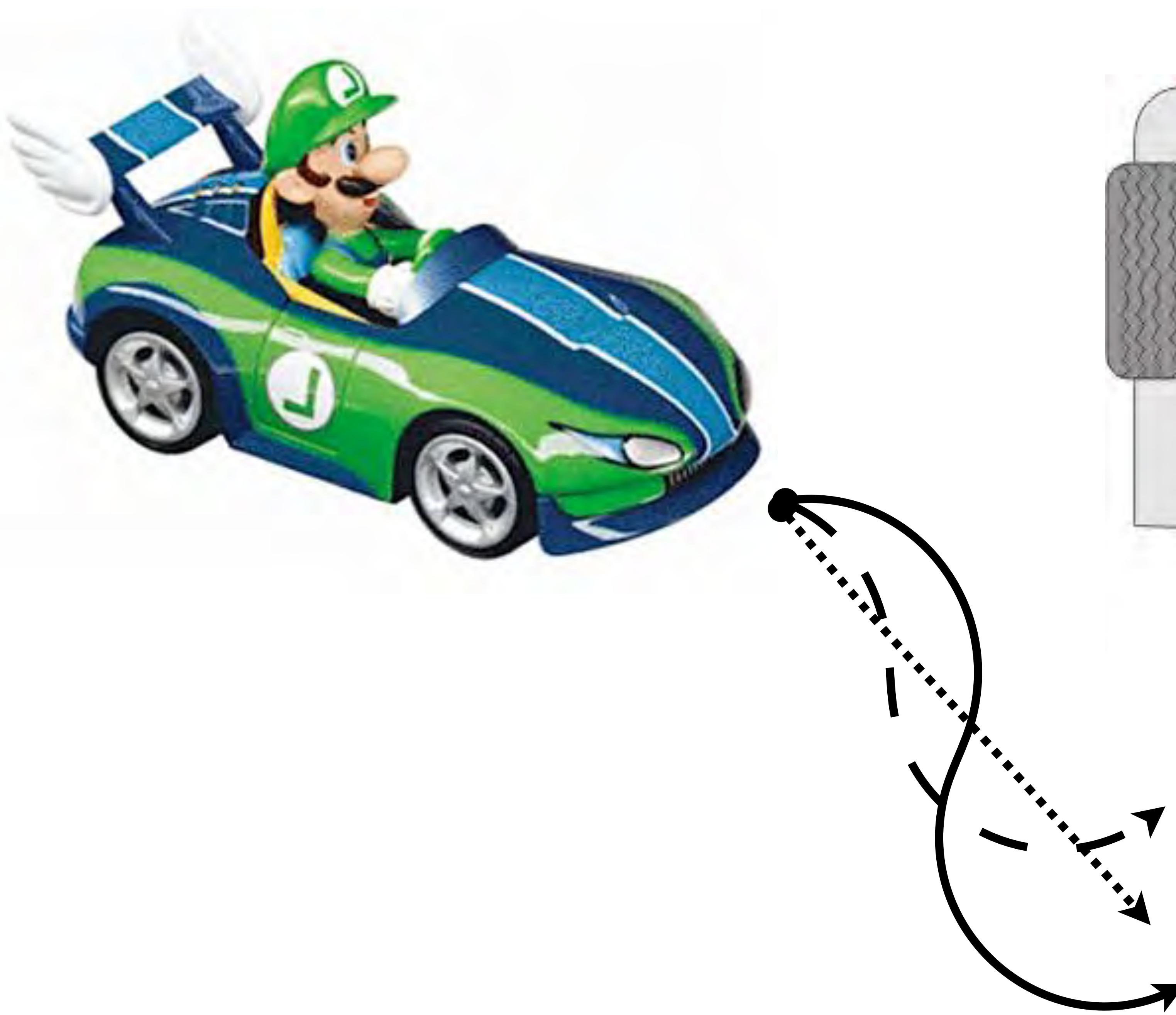


We have three main ways:
observation of nature, reflection and
experience.

- Observation collects facts
- Reflection combines them
- The experience verifies the result of the combination



To understand, and have a chance to predict, we need observations



To understand, and have a chance to predict, we need observations of a very complicated system: Earth



4

In spherical coordinates, the r , θ , and ϕ momentum equations are (note the convention used: ϕ is colatitude^[1]):

$$\rho \left(\frac{\partial u_r}{\partial t} + u_r \frac{\partial u_r}{\partial r} + \frac{u_\theta}{r \sin(\phi)} \frac{\partial u_r}{\partial \theta} + \frac{u_\phi}{r} \frac{\partial u_r}{\partial \phi} - \frac{u_\theta^2 + u_\phi^2}{r} \right) = -\frac{\partial p}{\partial r} + \rho g_r$$

$$\mu \left[\frac{1}{r^2} \frac{\partial}{\partial r} \left(r^2 \frac{\partial u_r}{\partial r} \right) + \frac{1}{r^2 \sin(\phi)^2} \frac{\partial^2 u_r}{\partial \theta^2} + \frac{1}{r^2 \sin(\phi)} \frac{\partial}{\partial \phi} \left(\sin(\phi) \frac{\partial u_r}{\partial \phi} \right) - 2 \frac{u_r + \frac{\partial u_\phi}{\partial \phi} + u_\phi \cot(\phi)}{r^2} + \frac{2}{r^2 \sin(\phi)} \frac{\partial u_\theta}{\partial \theta} \right]$$

$$\rho \left(\frac{\partial u_\theta}{\partial t} + u_r \frac{\partial u_\theta}{\partial r} + \frac{u_\theta}{r \sin(\phi)} \frac{\partial u_\theta}{\partial \theta} + \frac{u_\phi}{r} \frac{\partial u_\theta}{\partial \phi} + \frac{u_r u_\theta + u_\theta u_\phi \cot(\phi)}{r} \right) = -\frac{1}{r \sin(\phi)} \frac{\partial p}{\partial \theta} + \rho g_\theta$$

$$\mu \left[\frac{1}{r^2} \frac{\partial}{\partial r} \left(r^2 \frac{\partial u_\theta}{\partial r} \right) + \frac{1}{r^2 \sin(\phi)^2} \frac{\partial^2 u_\theta}{\partial \theta^2} + \frac{1}{r^2 \sin(\phi)} \frac{\partial}{\partial \phi} \left(\sin(\phi) \frac{\partial u_\theta}{\partial \phi} \right) + \frac{2 \frac{\partial u_r}{\partial \theta} + 2 \cos(\phi) \frac{\partial u_\theta}{\partial \theta} - u_\theta}{r^2 \sin(\phi)^2} \right]$$

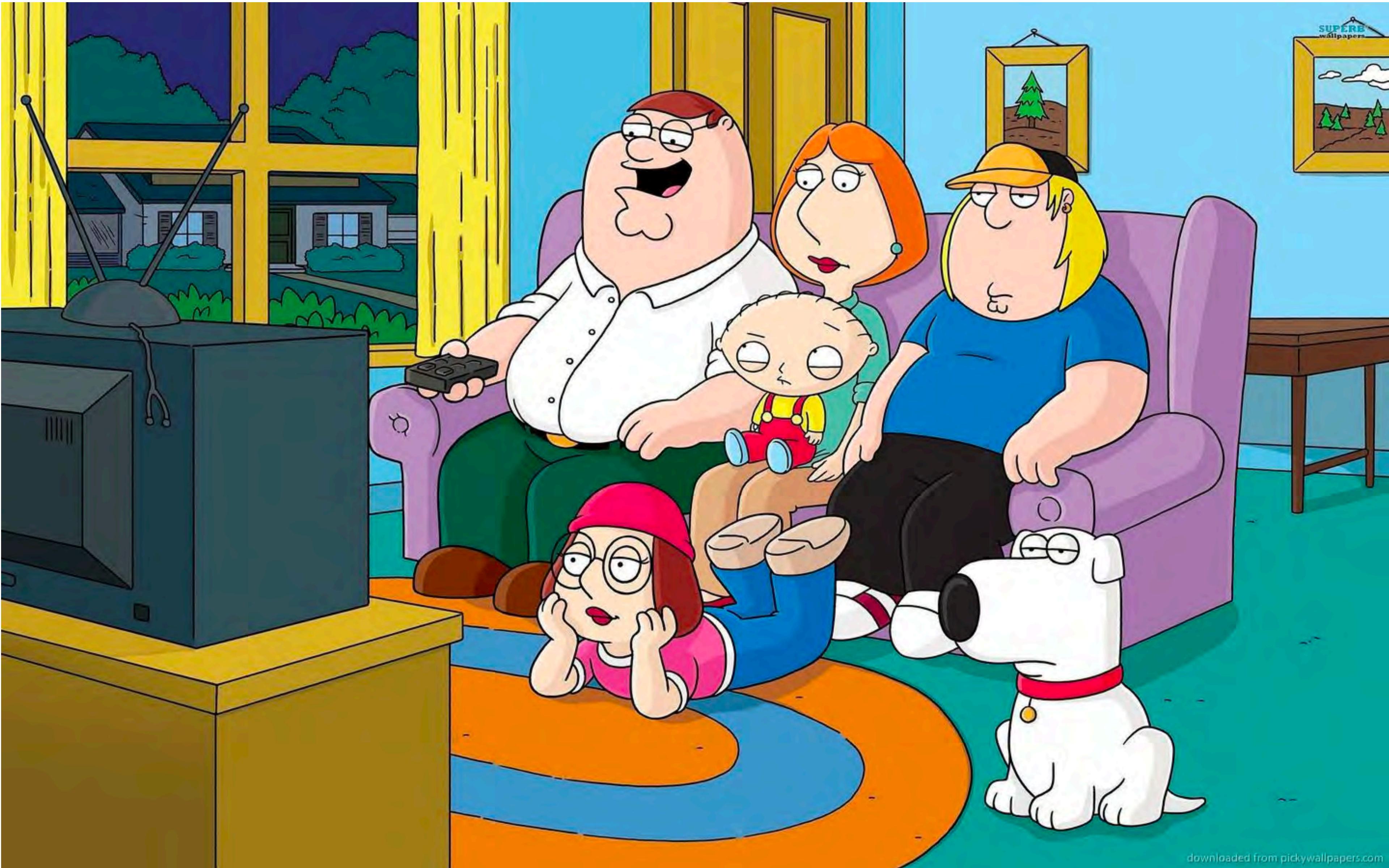
$$\rho \left(\frac{\partial u_\phi}{\partial t} + u_r \frac{\partial u_\phi}{\partial r} + \frac{u_\theta}{r \sin(\phi)} \frac{\partial u_\phi}{\partial \theta} + \frac{u_\phi}{r} \frac{\partial u_\phi}{\partial \phi} + \frac{u_r u_\phi - u_\theta^2 \cot(\phi)}{r} \right) = -\frac{1}{r} \frac{\partial p}{\partial \phi} + \rho g_\phi$$

$$\mu \left[\frac{1}{r^2} \frac{\partial}{\partial r} \left(r^2 \frac{\partial u_\phi}{\partial r} \right) + \frac{1}{r^2 \sin(\phi)^2} \frac{\partial^2 u_\phi}{\partial \theta^2} + \frac{1}{r^2 \sin(\phi)} \frac{\partial}{\partial \phi} \left(\sin(\phi) \frac{\partial u_\phi}{\partial \phi} \right) + \frac{2}{r^2} \frac{\partial u_r}{\partial \phi} - \frac{u_\phi + 2 \cos(\phi) \frac{\partial u_\theta}{\partial \theta}}{r^2 \sin(\phi)^2} \right]$$

Mass continuity will read:

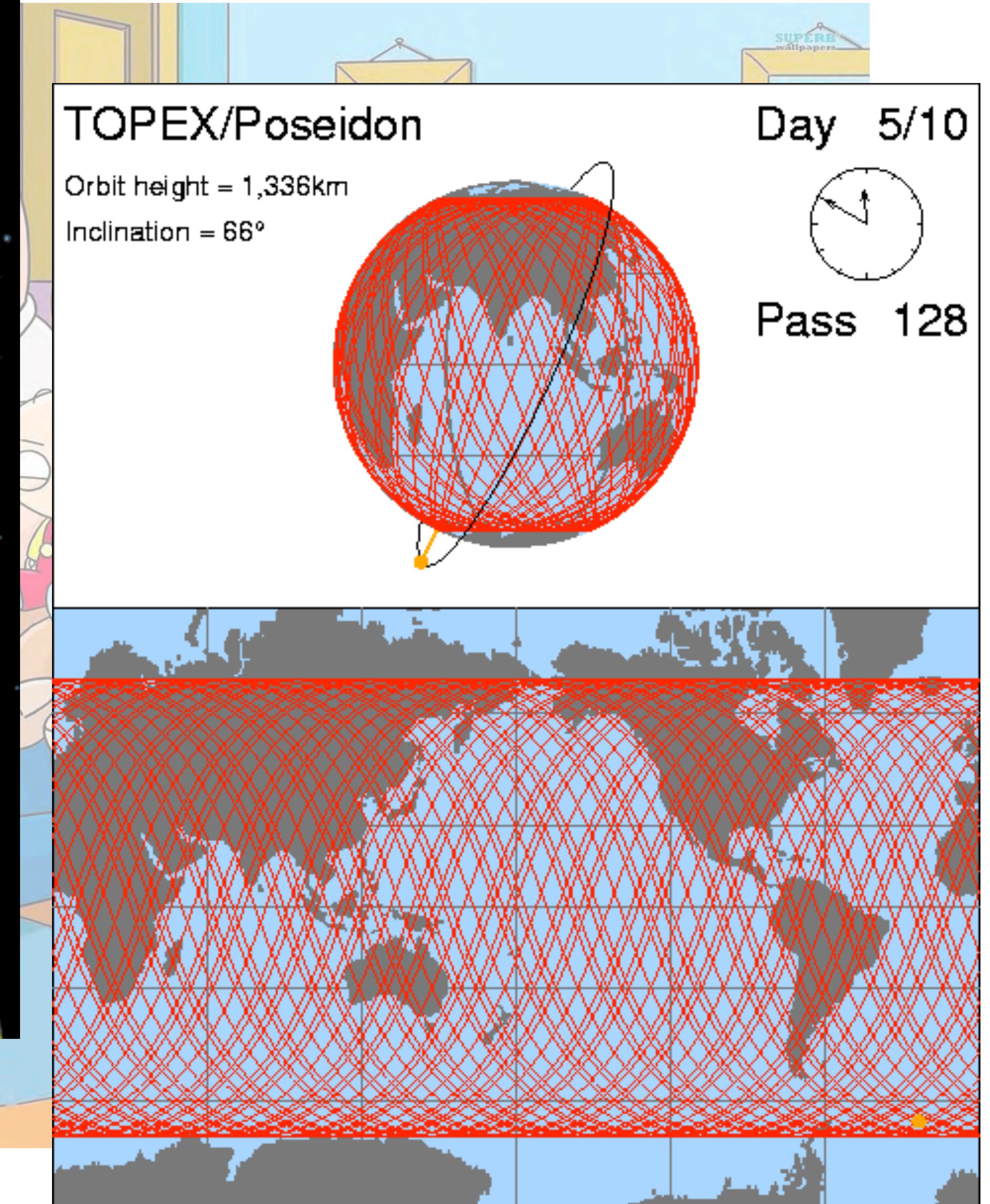
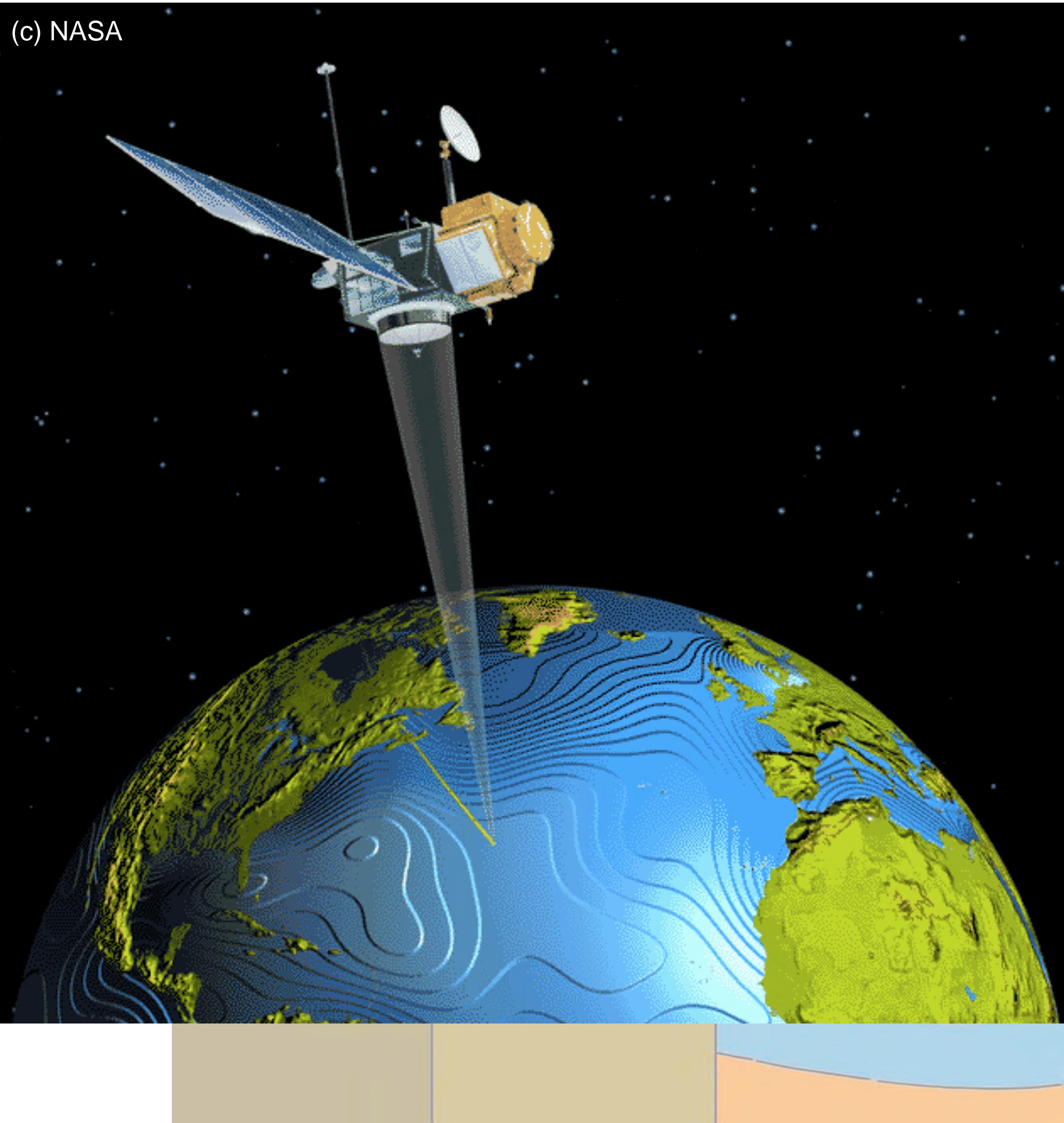
$$\frac{1}{r^2} \frac{\partial}{\partial r} \left(r^2 u_r \right) + \frac{1}{r \sin(\phi)} \frac{\partial u_\theta}{\partial \theta} + \frac{1}{r \sin(\phi)} \frac{\partial}{\partial \phi} \left(\sin(\phi) u_\phi \right) = 0$$

Observer position ?



Remote

Observer position ?



Remote: superficial / integrated

Observer position ?



(c) BBC

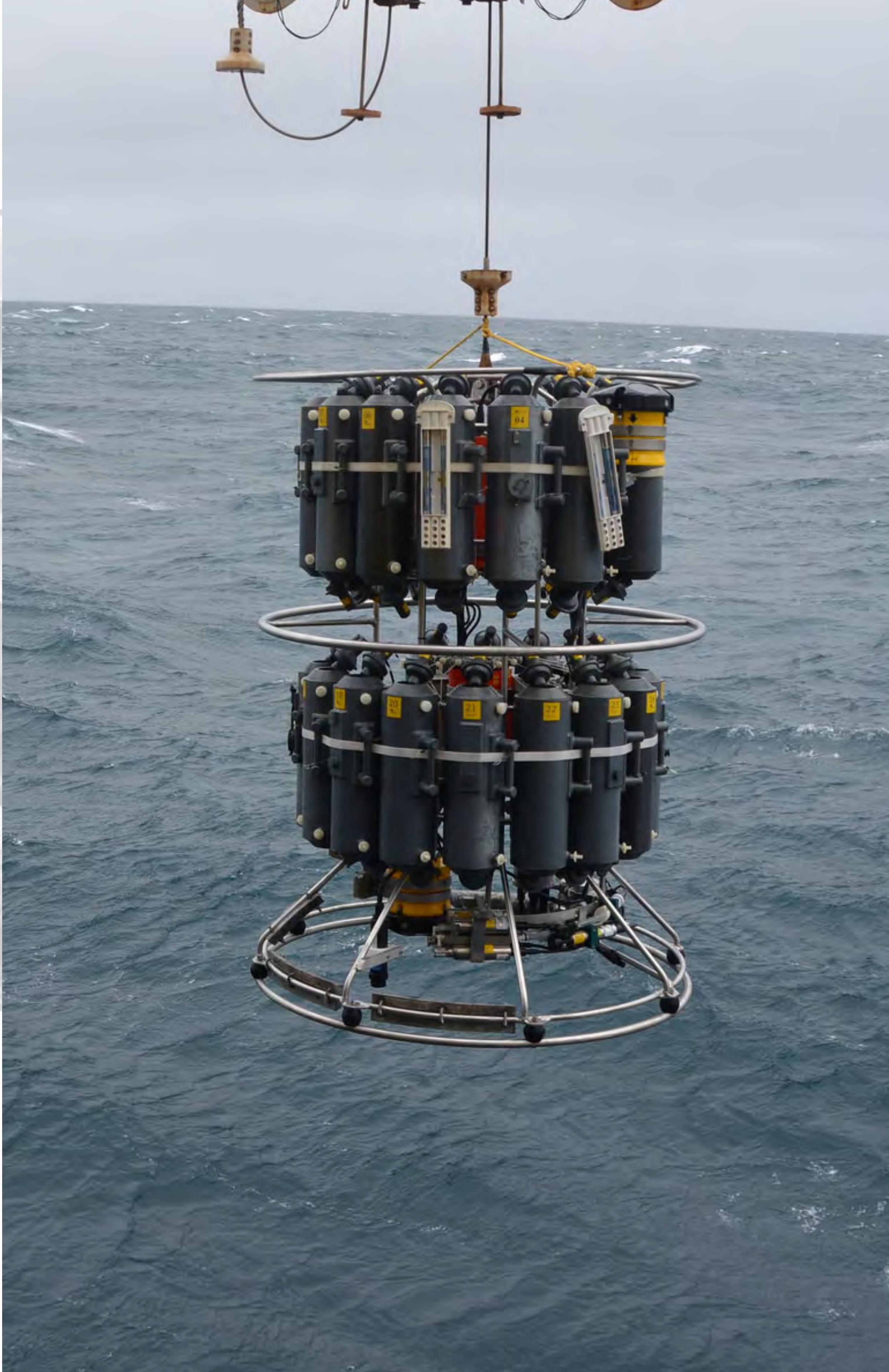
BBC war correspondent Robin Duff, D-day

In situ

latin for “in position”

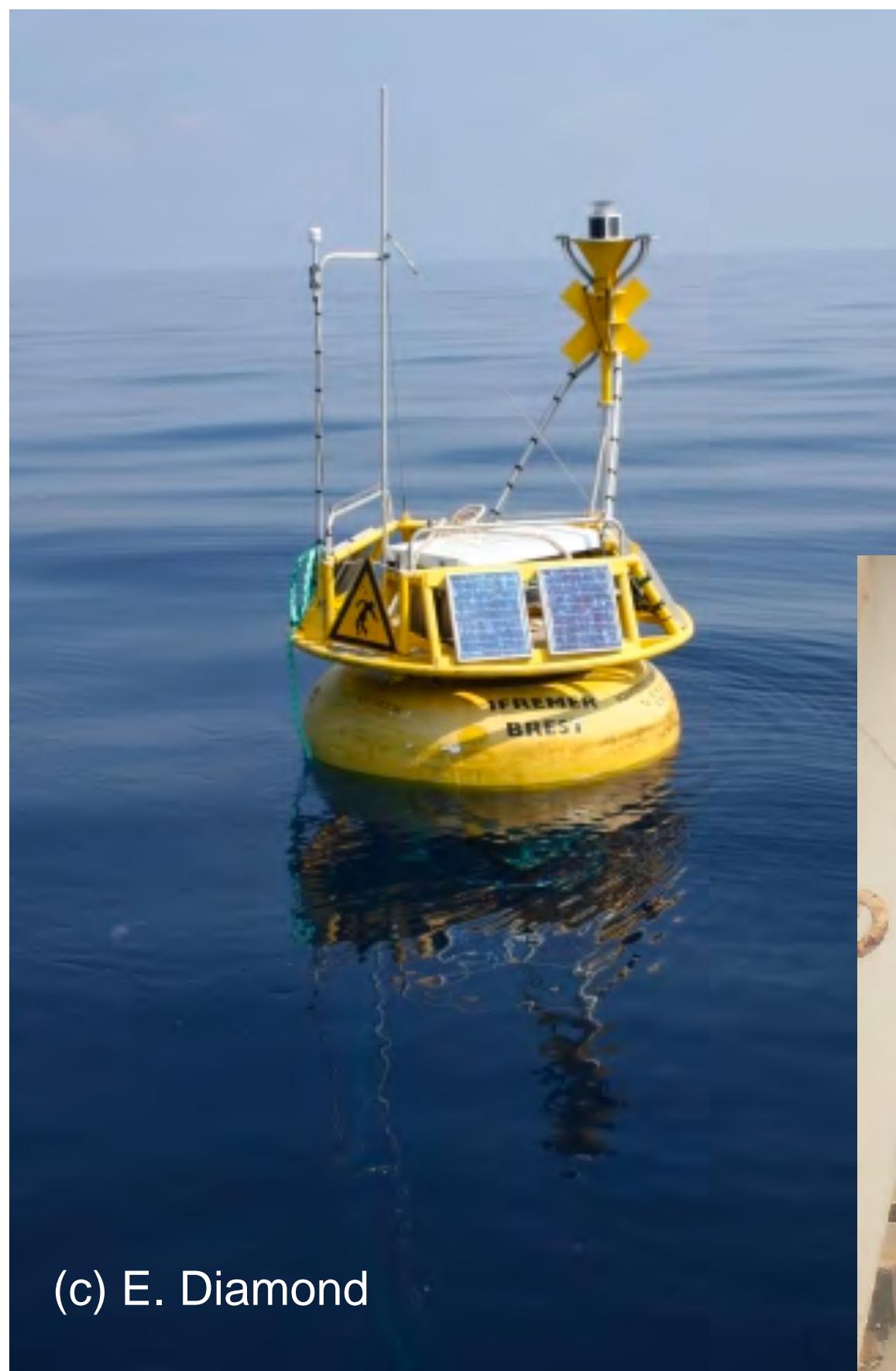
Observer position ?

8



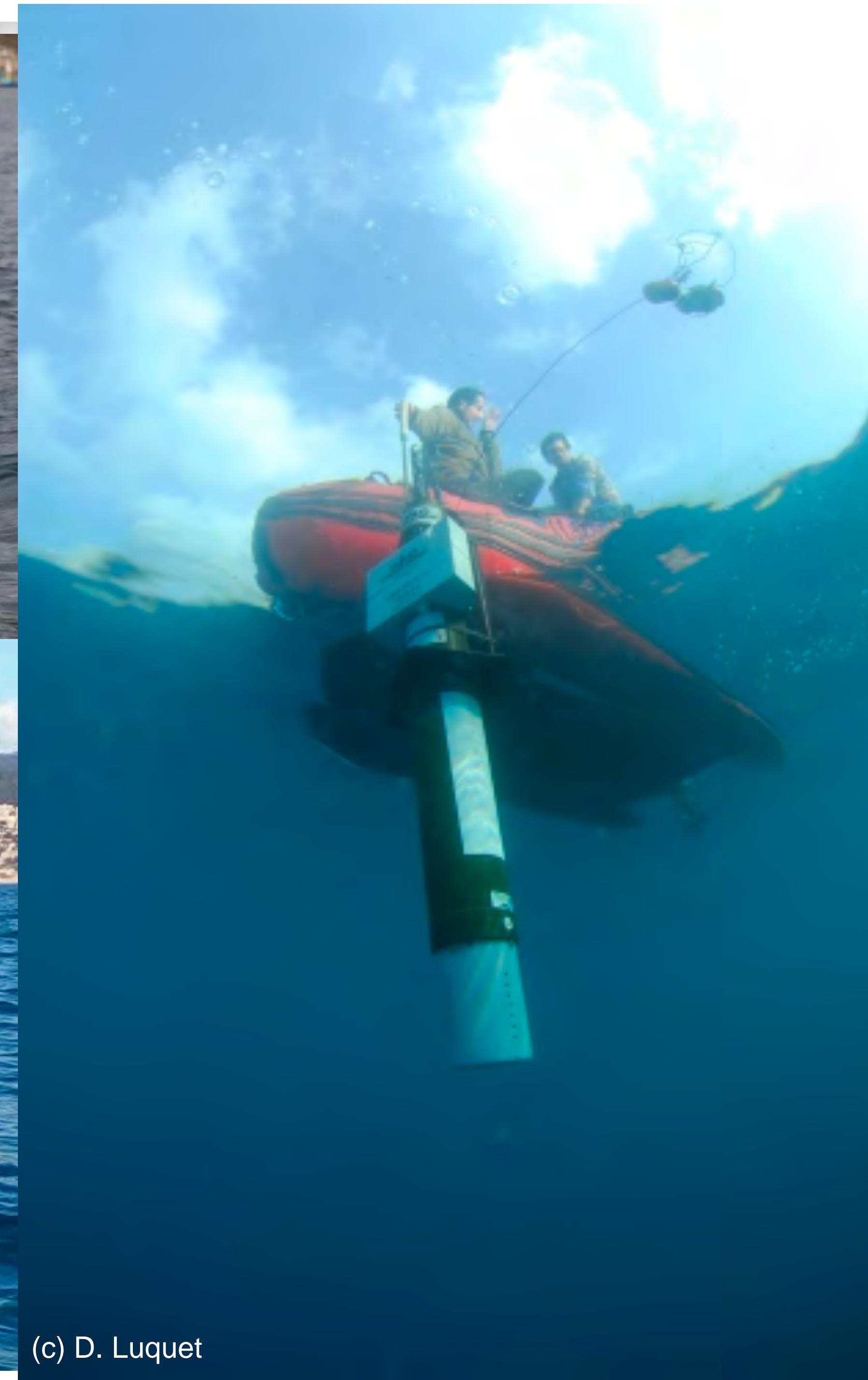
In situ: in depth / interior

Observer position ?



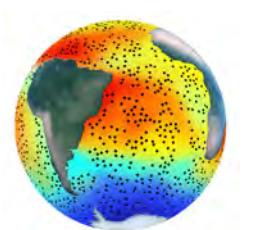
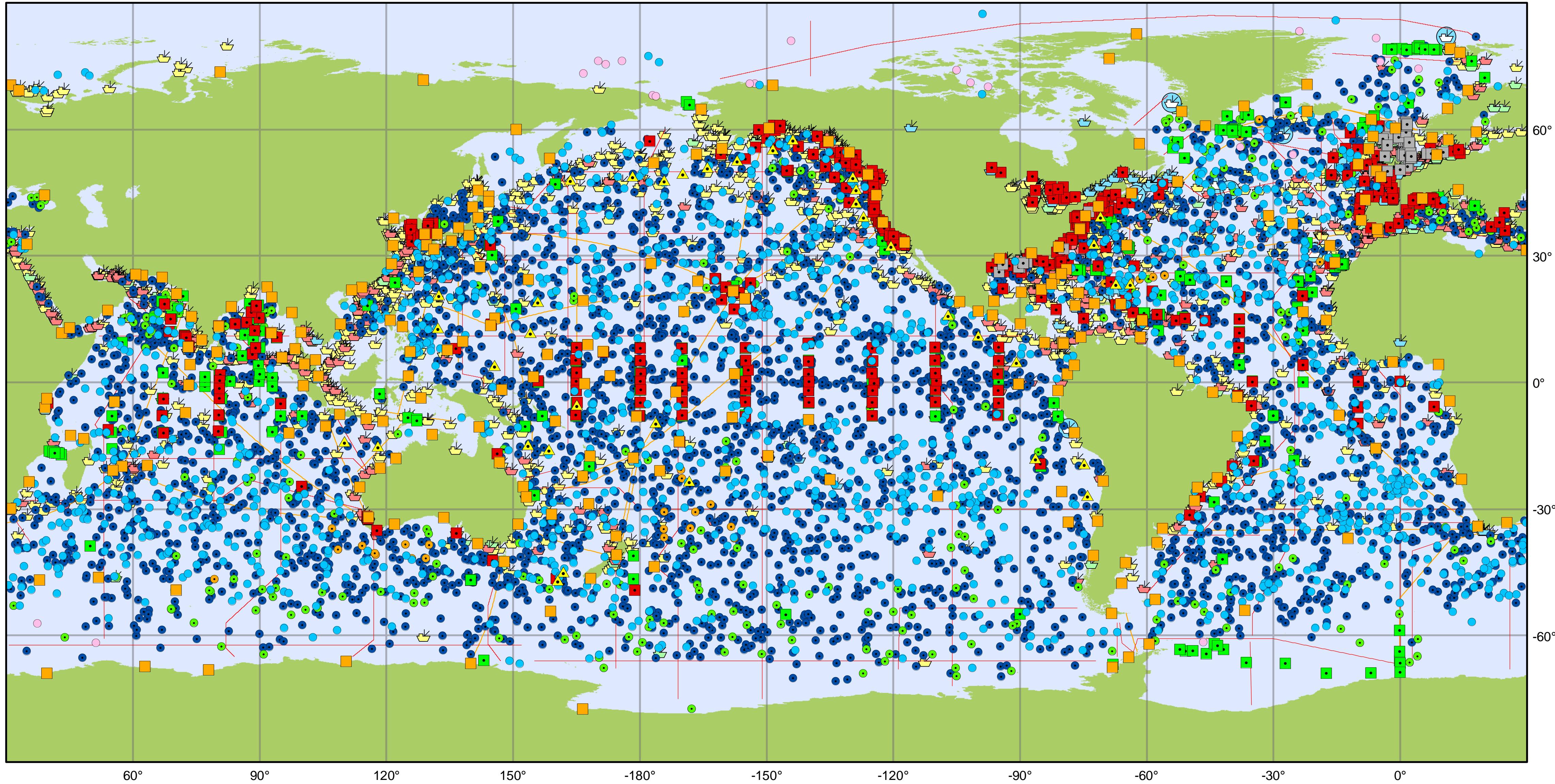
In situ: in depth / interior

Observer position ?

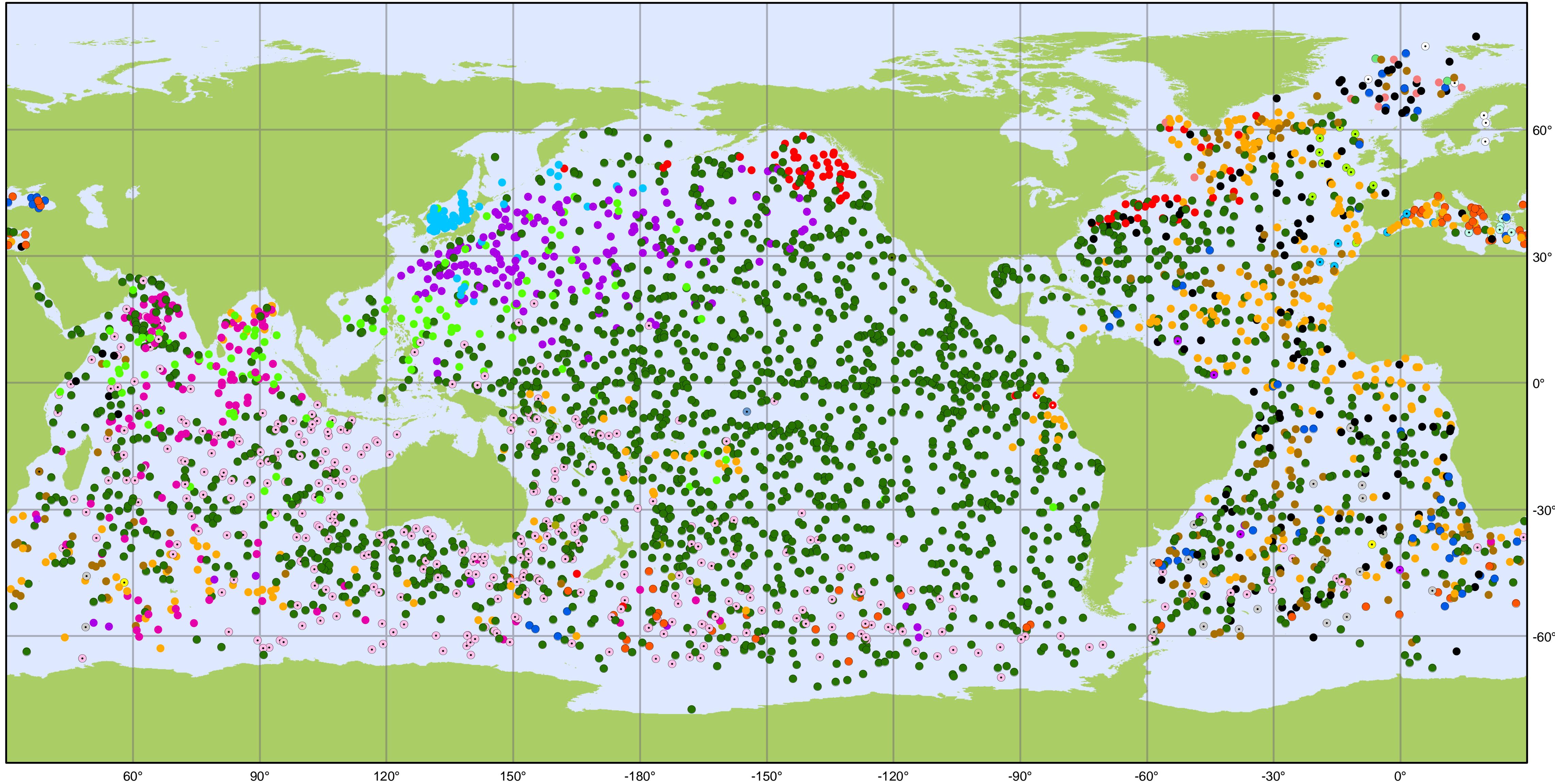


10

In situ ocean observations



In situ ocean observations



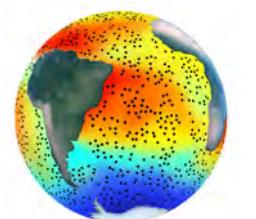
Argo

National contributions - 3904 Operational Floats

May 2017

Latest location of operational floats (data distributed within the last 30 days)

- | | | | | | |
|-------------------|-----------------|----------------|--------------------|---------------------------|--------------|
| • ARGENTINA (2) | • ECUADOR (1) | • GREECE (8) | • KENYA (1) | • NORWAY (10) | • UK (156) |
| • AUSTRALIA (370) | • EUROPE (59) | • INDIA (130) | • MAURITIUS (1) | • PERU (3) | • USA (2142) |
| • BRAZIL (6) | • FINLAND (6) | • IRELAND (10) | • MEXICO (2) | • POLAND (2) | |
| • CANADA (74) | • FRANCE (319) | • ITALY (70) | • NETHERLANDS (26) | • KOREA, REPUBLIC OF (62) | |
| • CHINA (116) | • GERMANY (143) | • JAPAN (171) | • NEW ZEALAND (7) | • SPAIN (7) | |

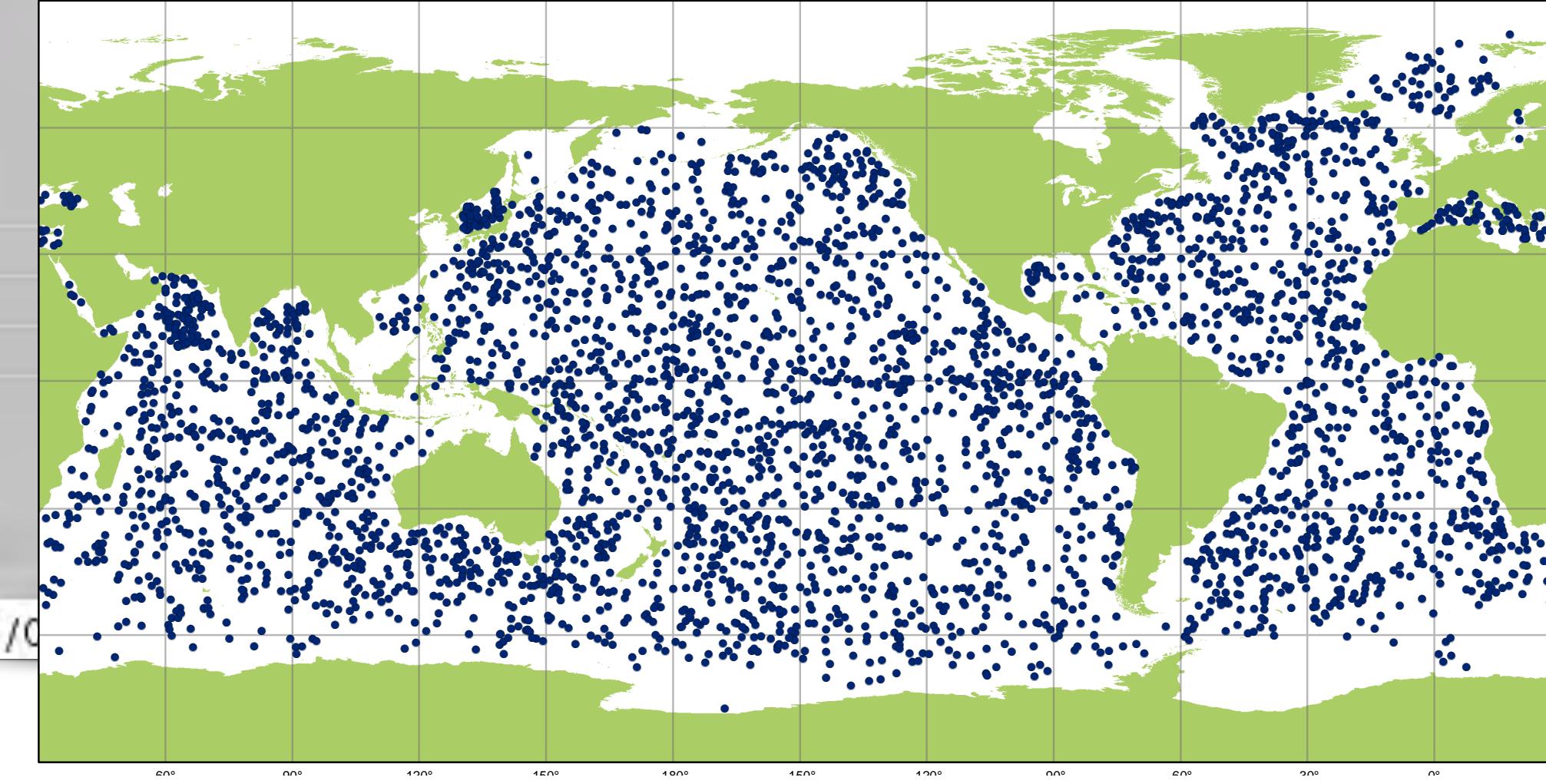
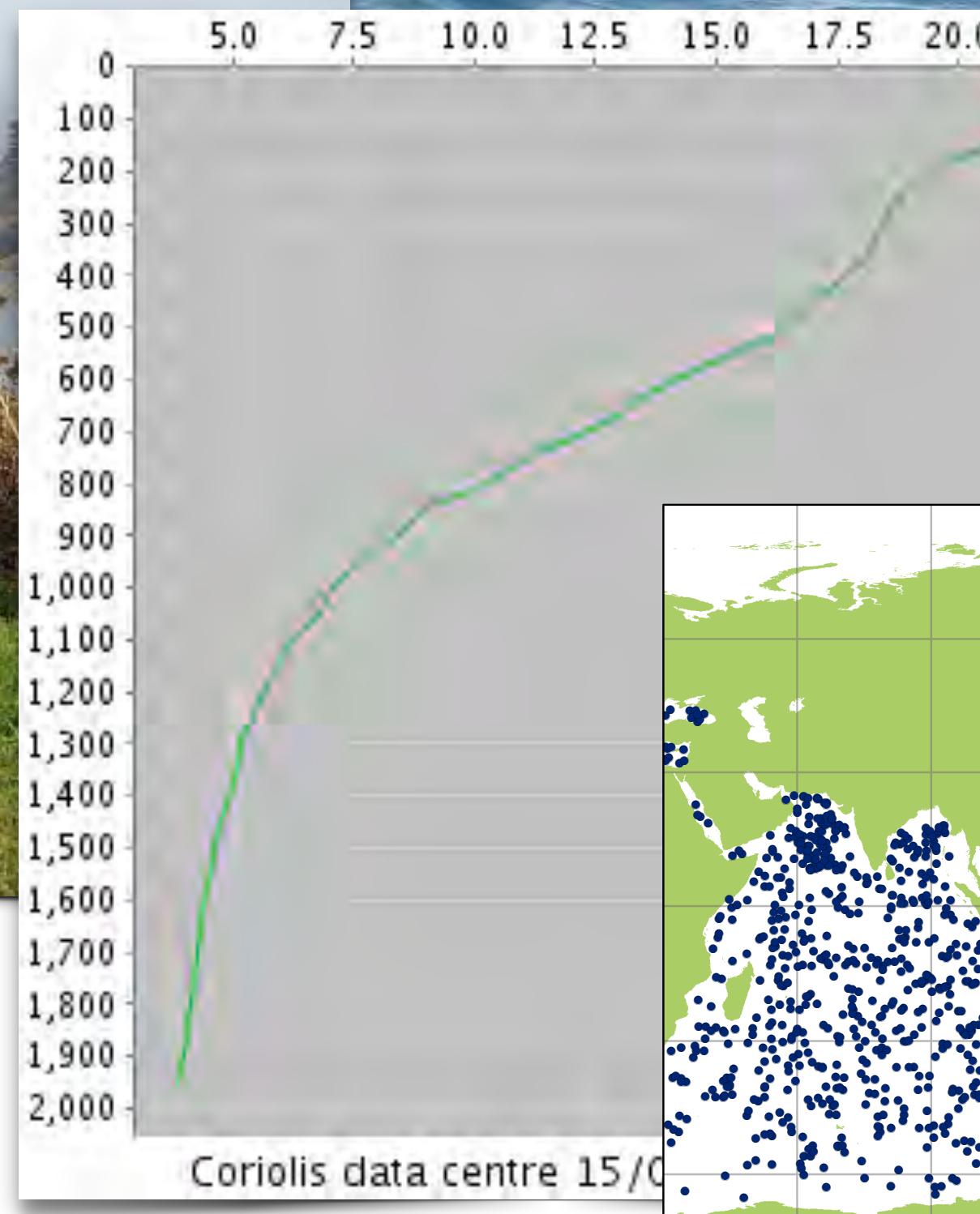




The observation network

Argo is based on autonomous probes
measuring temperature & salinity vertical profils
in a massive network covering the global ocean in real time

13



Coriolis data centre 15/0



The observation network

Argo is based on autonomous probes

measuring temperature & salinity vertical profiles

in a massive network covering the global ocean in real time



probe = profiling float

- ◆ over 4-years of lifetime
- ◆ perpetual cycle: run the same program in loop
- ◆ able to go up and down alone
- ◆ satellite transmission of measurements: data obtained in real time

The observation network

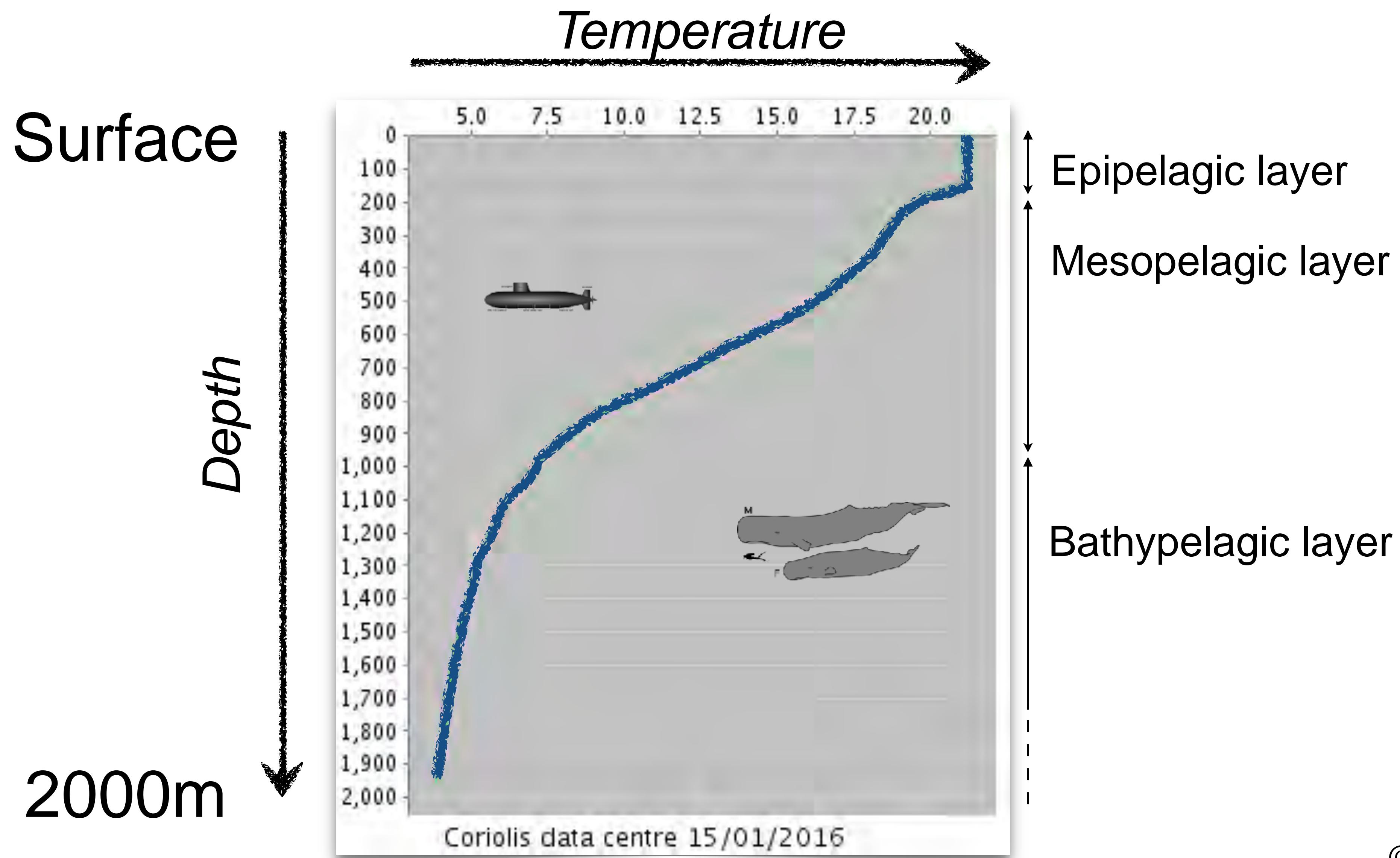


Flotteur profileur
profiling float



The observation network

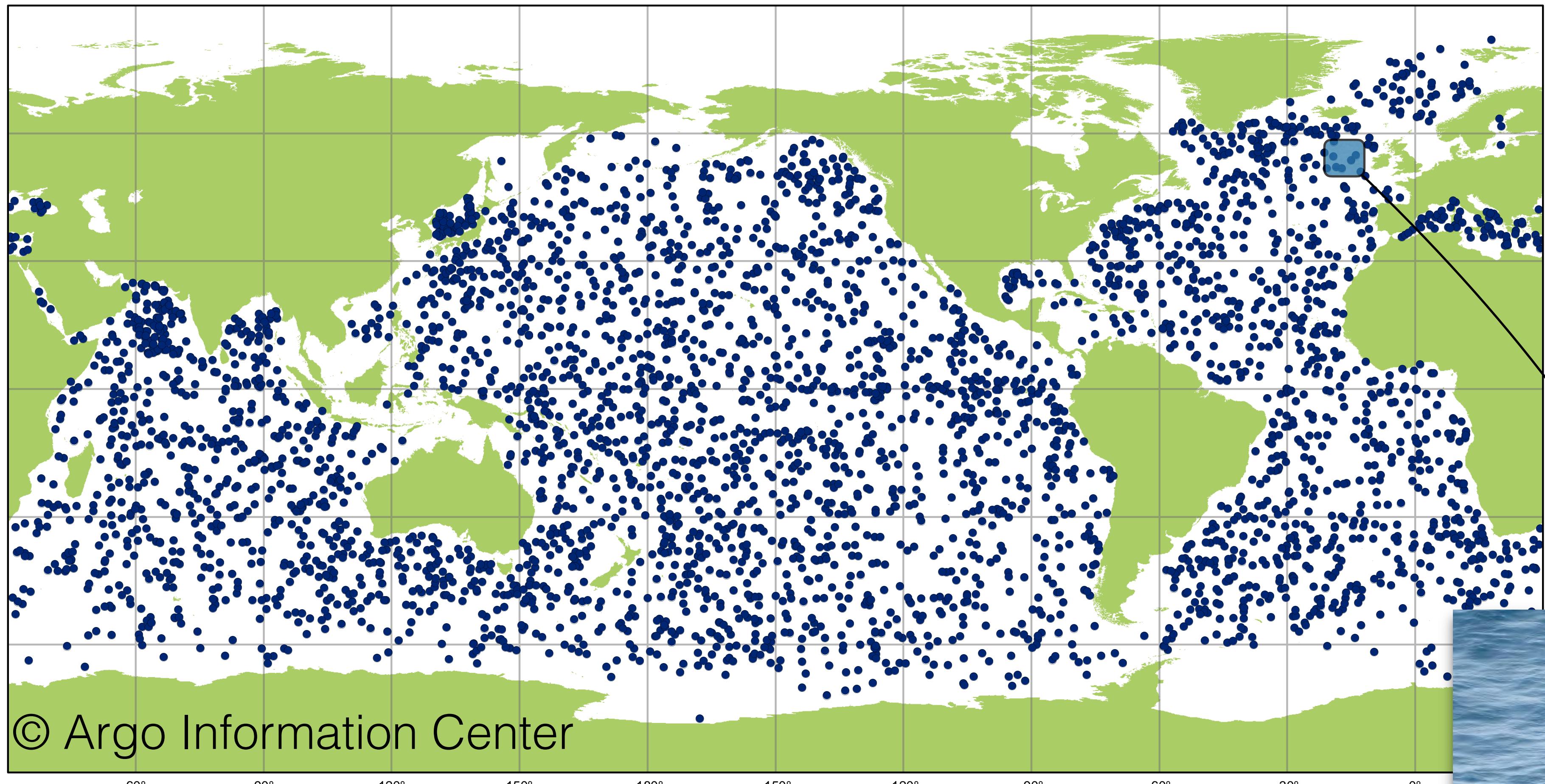
Argo is based on autonomous probes
measuring temperature & salinity vertical profils
in a massive network covering the global ocean in real time





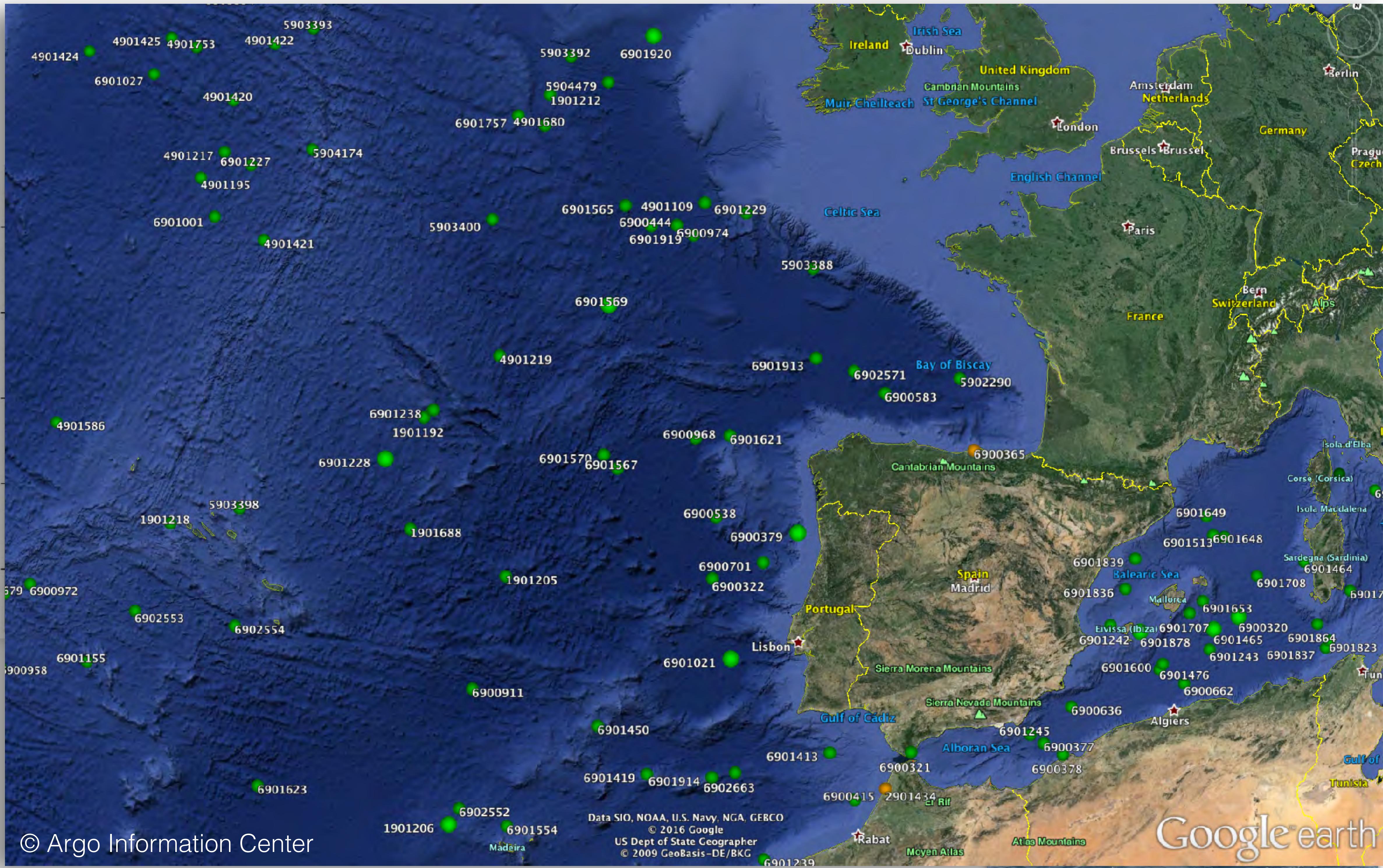
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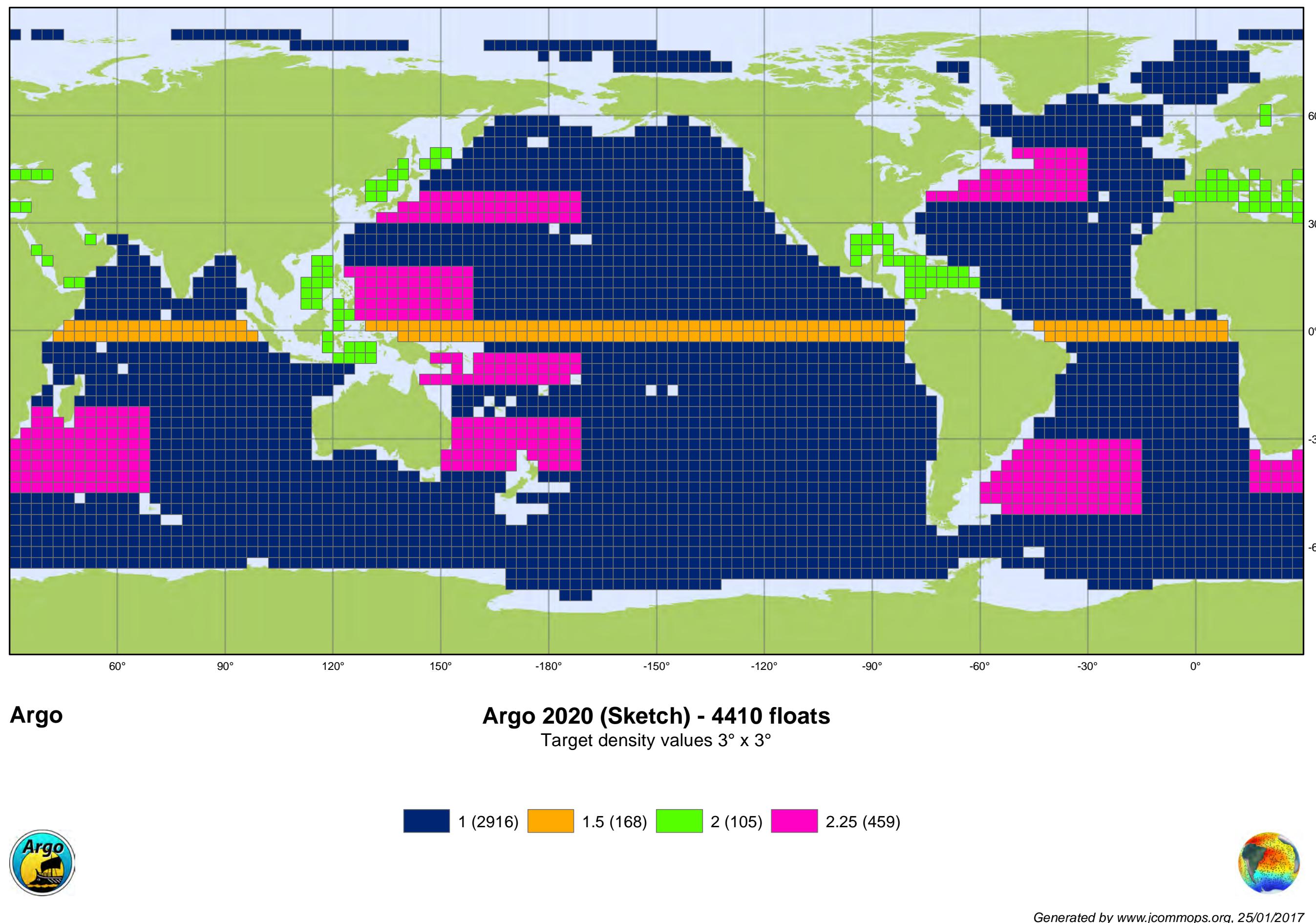
The observation network





The observation network

is in perpetual evolution, in design and technology, to address new scientific questions and challenges



Scientists need more systematic and appropriate measurements in real time for:

- turbulent regions
- equator/marginal seas
- polar oceans
- deep ocean



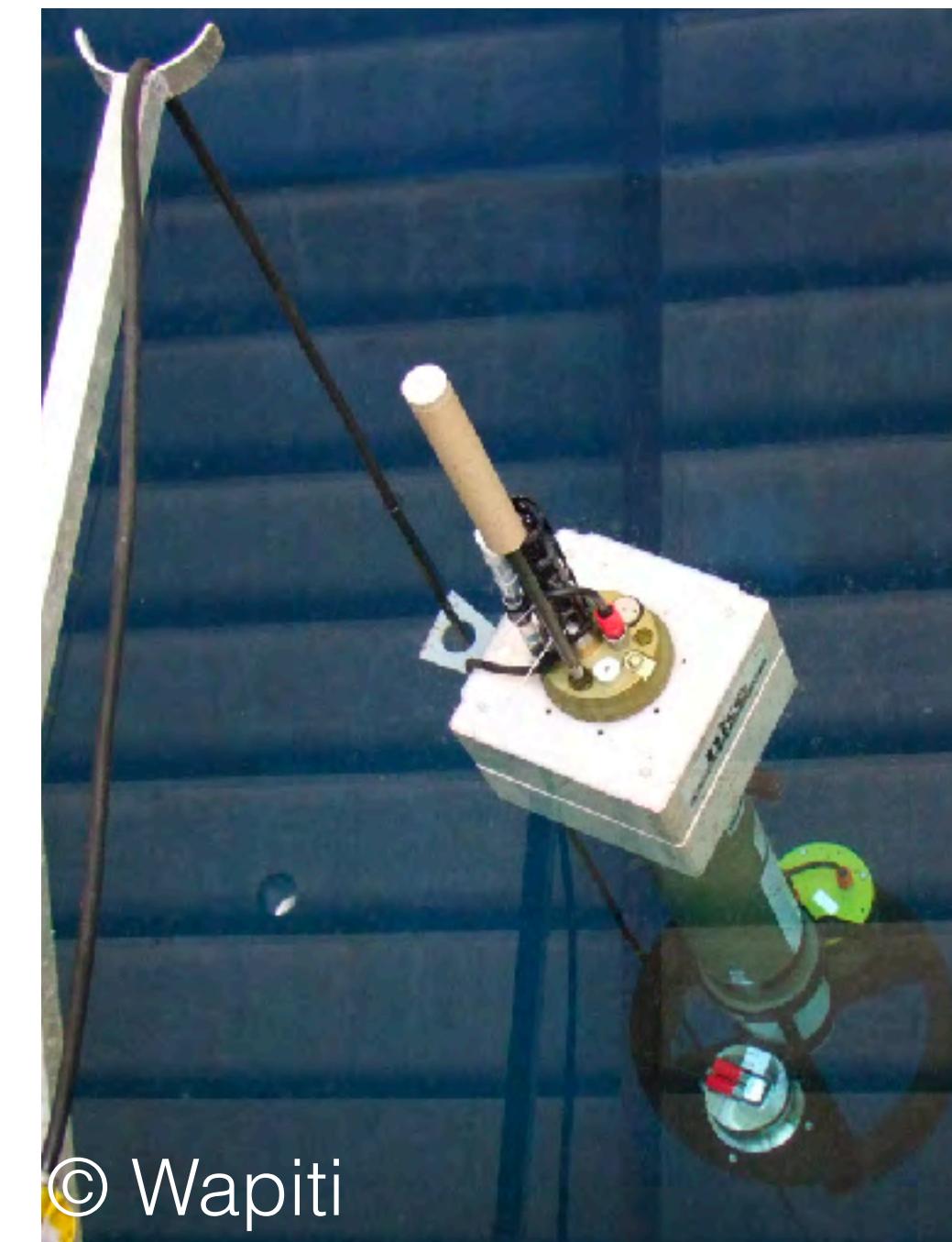
The observation network

is in perpetual evolution, in design and technology, to address new scientific questions and challenges



Scientists need more variables:

- Biogeochemistry
- Currents/Turbulence
- Sound !





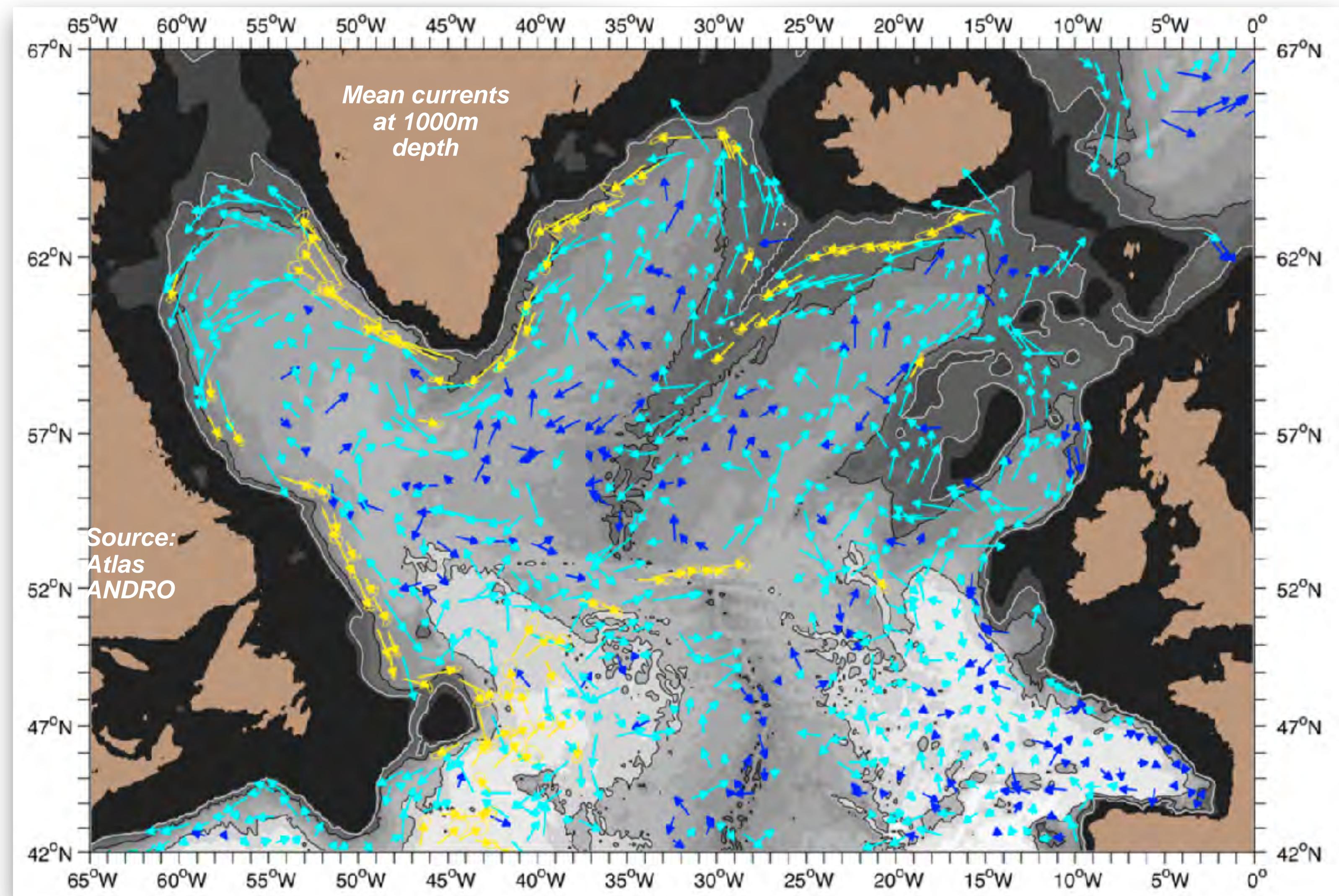
Observations from FREE, OPEN, CURATED !

Access to data for scientists: <ftp://ftp.ifremer.fr/ifremer/argo> or <ftp://usgsdae.org/pub/outgoing/argo>

Many applications, 1 scientific article per day

21

Observations of
currents



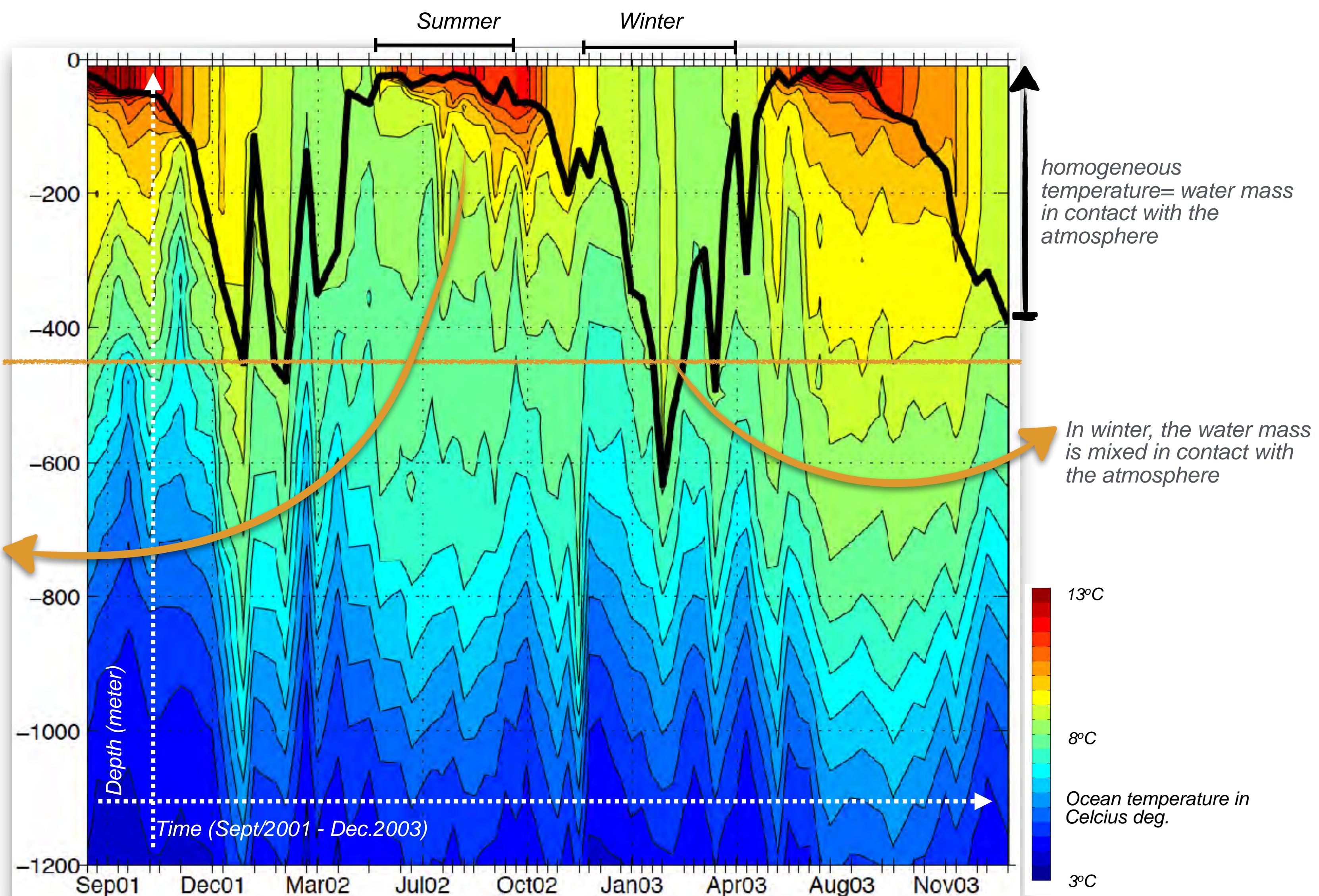


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Many applications, 1 scientific article per day

Ocean interior
structure and
variability





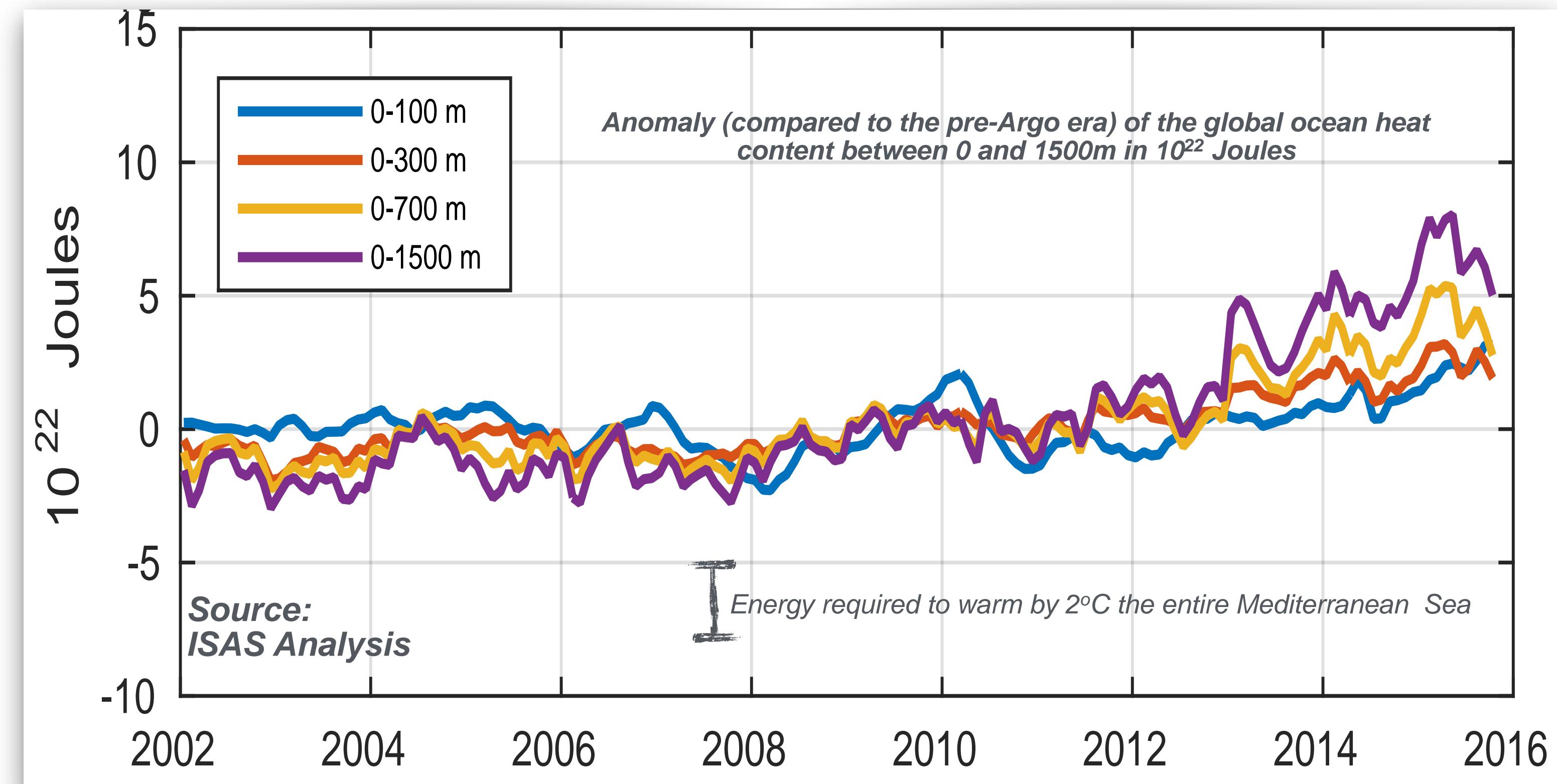
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Ocean heat
content

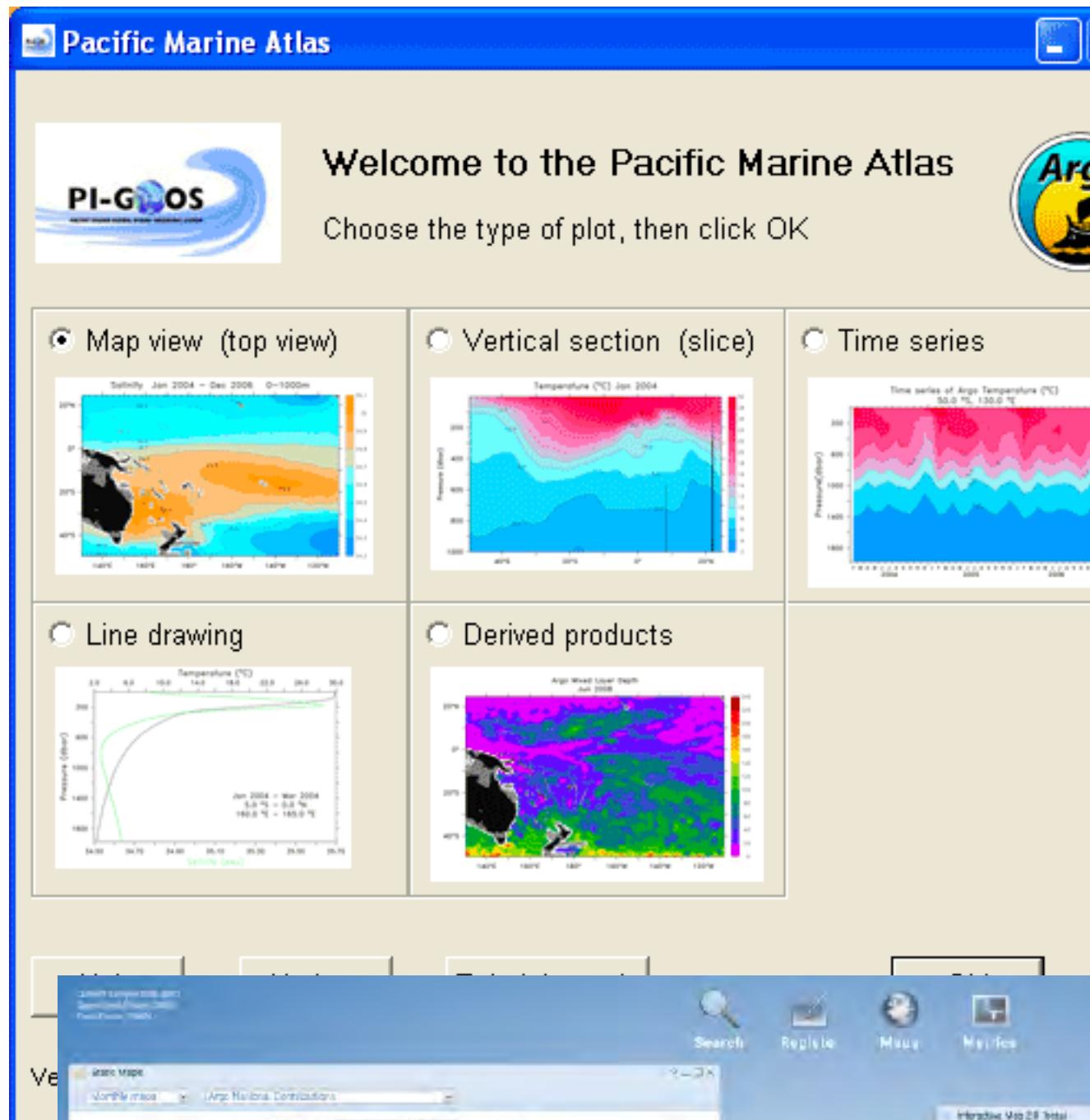
Earth Energy Balance
Regional Sea Level Rise



Observations from FREE, OPEN, CURATED !

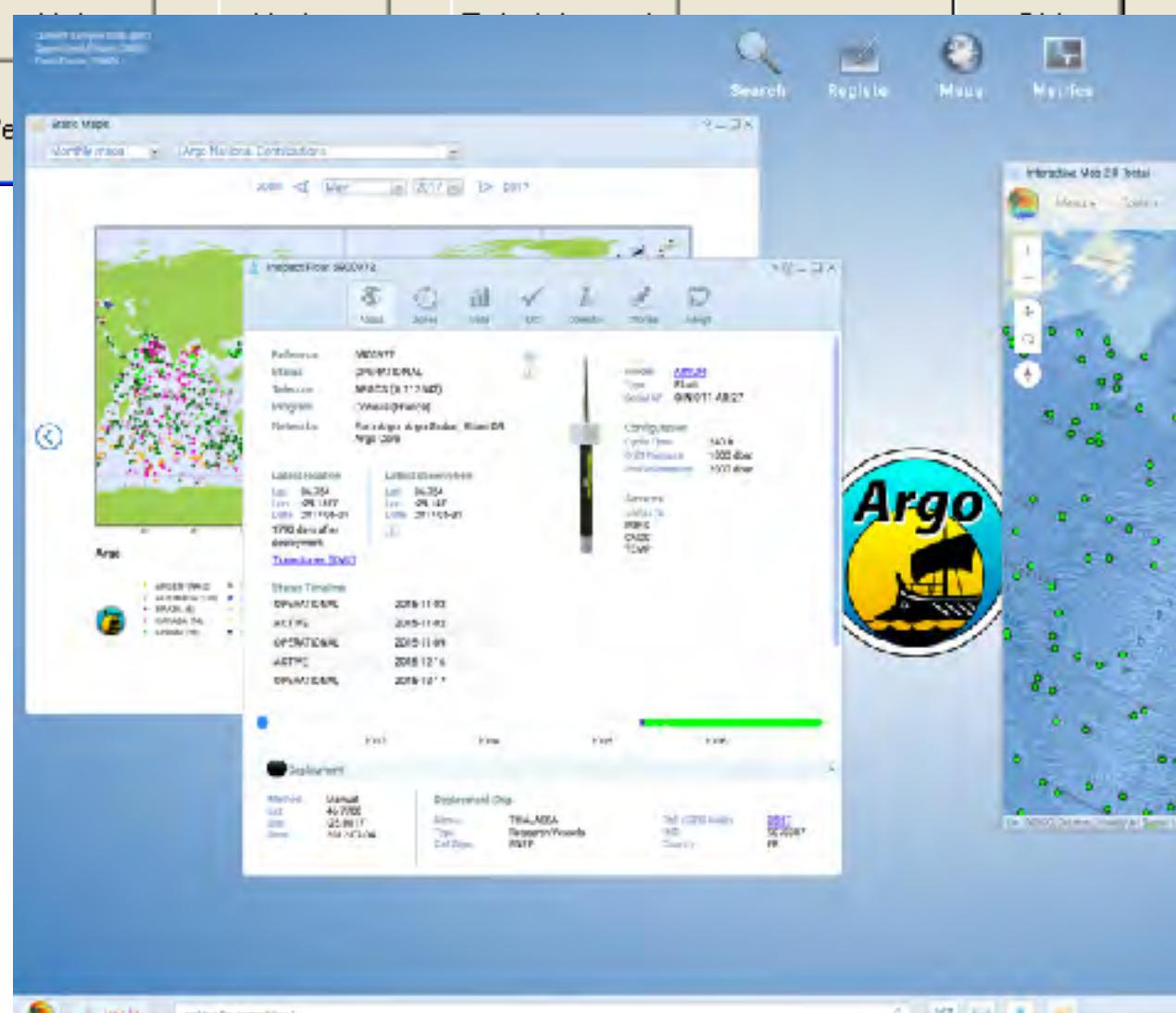
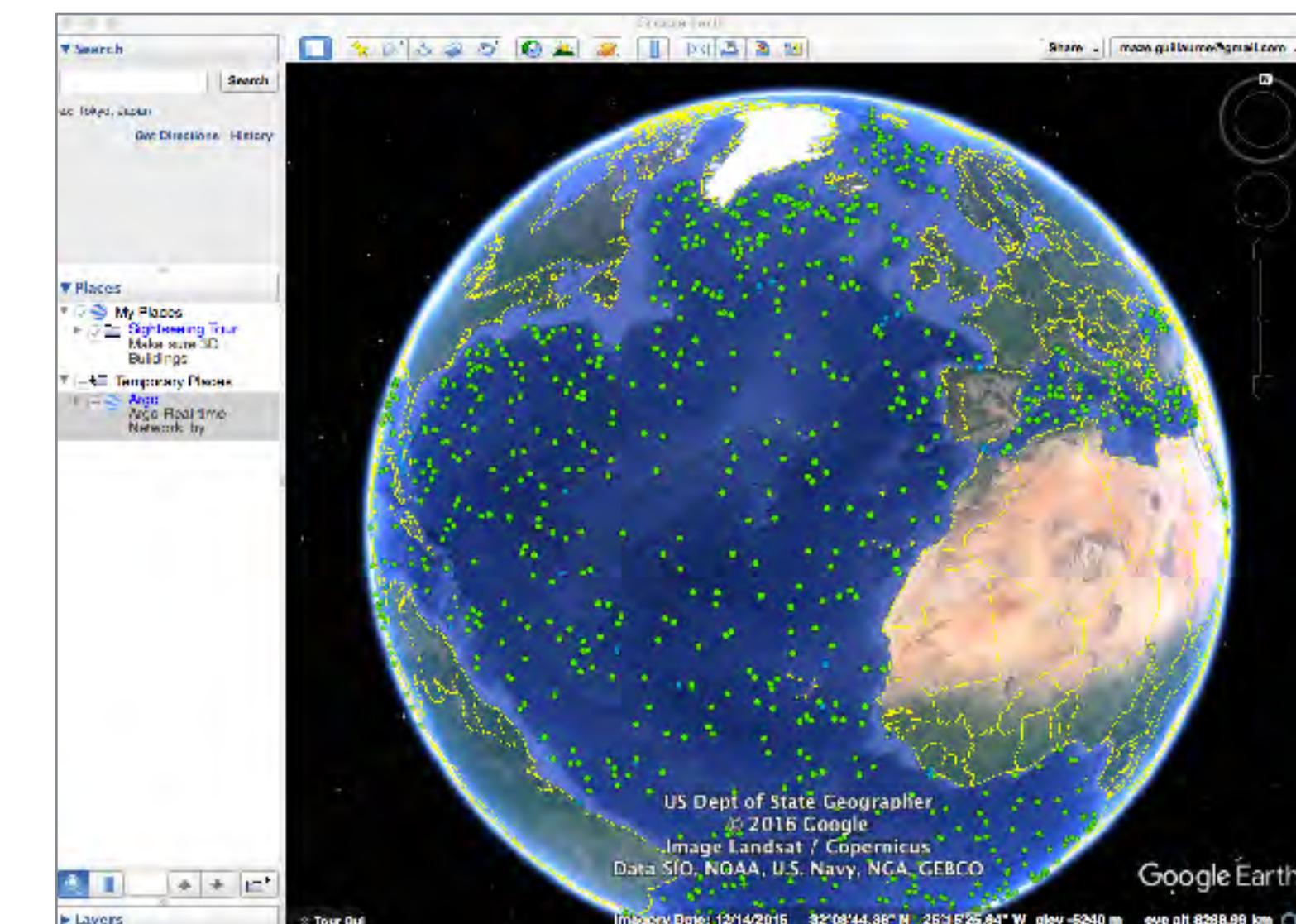


Global Marine Argo Atlas

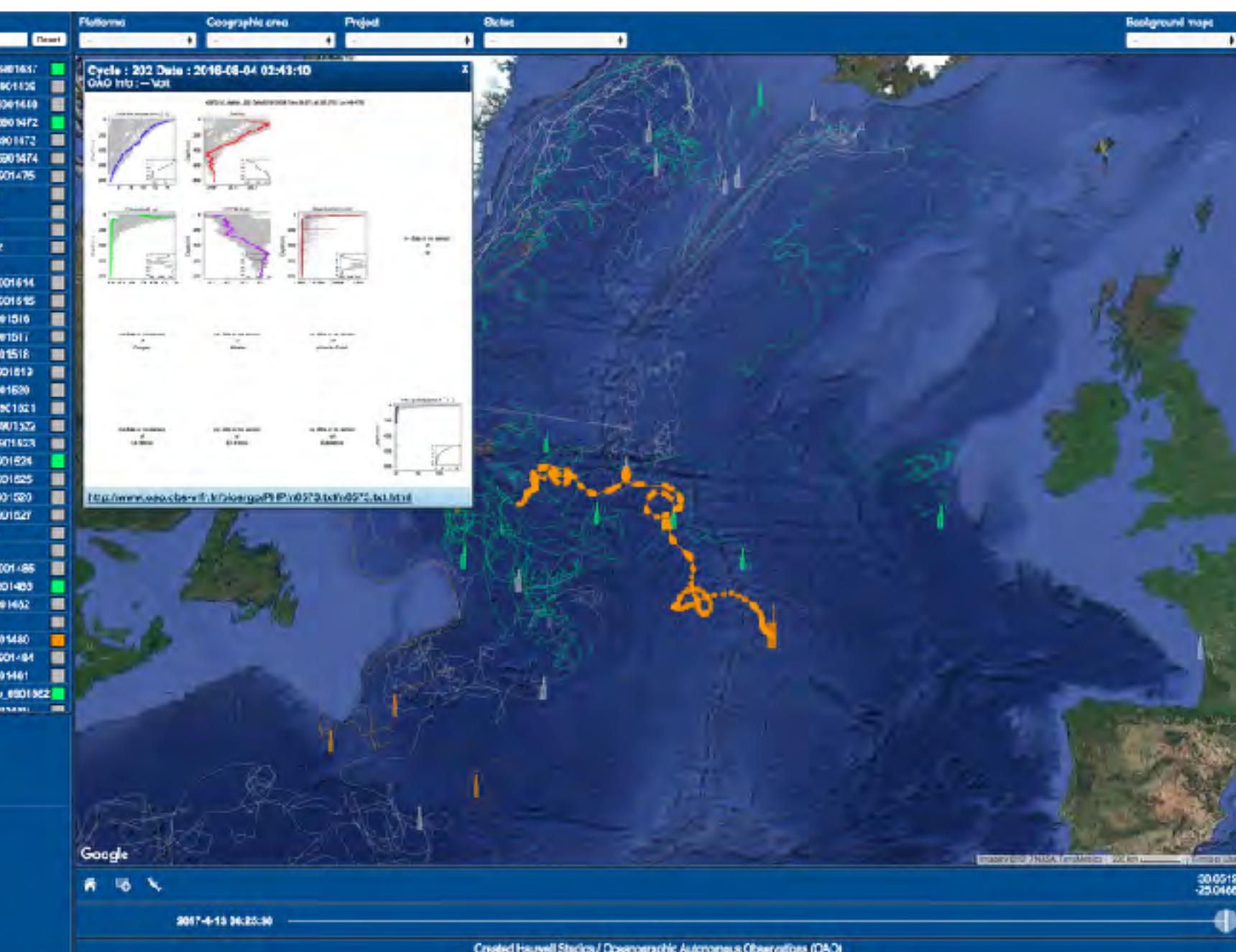
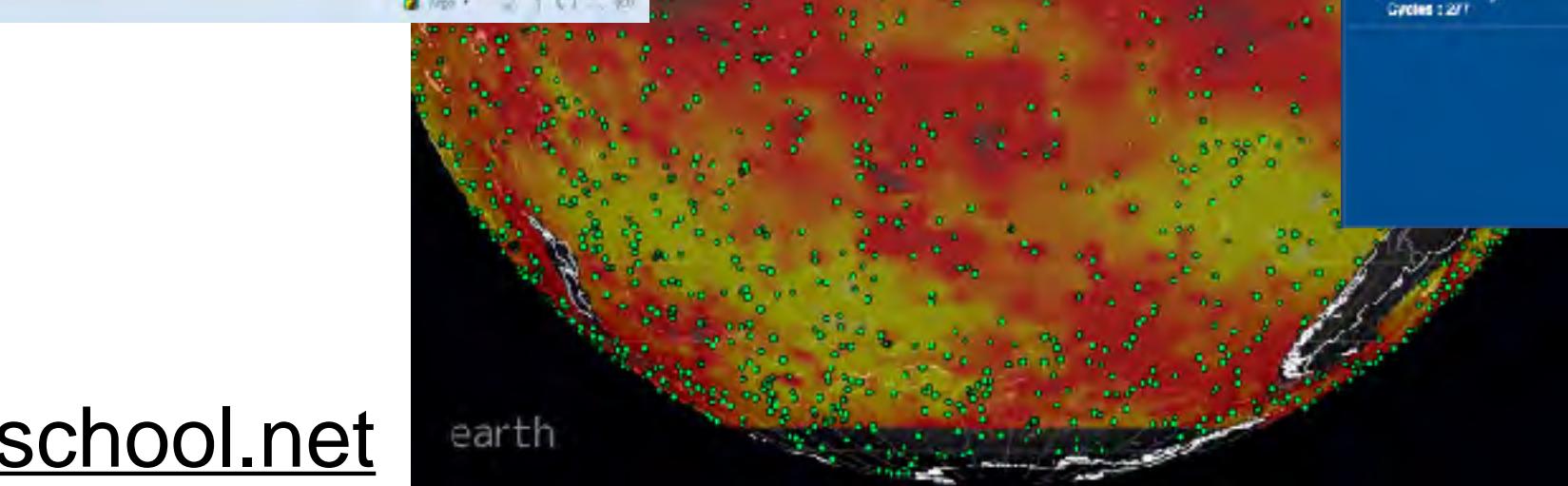
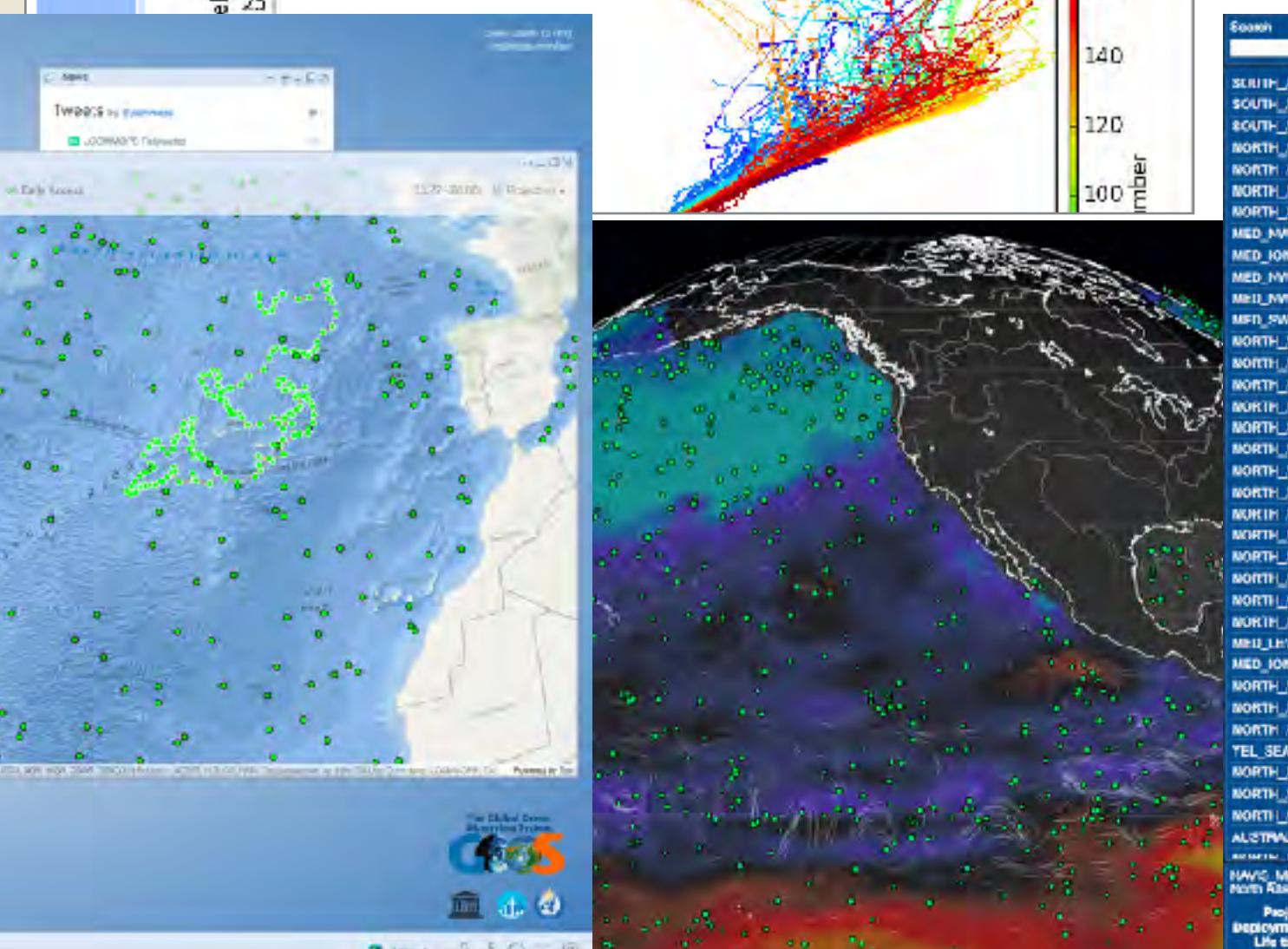


argodatamgt.org

argo.jcommops.org/argo.kml



argo.jcommops.org



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24